N.A.C.A. BULLETIN

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BREAK-EVEN ANALYSIS—COMMON GROUND FOR THE ECONOMIST AND THE COST ACCOUNTANT

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This article discusses the break-even point concept in general terms and the separate but not wholly dissimilar interest of the economist and the accountant in the concept and its applications. The author takes cognizance of unsolved problems affecting any form of presentation of price, output, and cost relationships, comments on the relative usefulness of summary and more studied procedures for preparing break-even charts, and appraises briefly the place held by such charts as mirrors of operating situations.

THE primary function of the industrial accountant is that of providing management with information which is useful in establishing policies and in maintaining effective control of business operations. It is the purpose of this paper to make a brief survey of the development and current status of one phase of that job, the analysis and presentation of the interrelationship of costs, volume, and profit. It is evident that the end product of such analysis, the break-even chart, once lightly dismissed by many as a gadget, has become in recent years an accepted, if not an indispensable, accounting tool. In this paper, "break-even analysis" will be used to denote any systematic portrayal of past or projected costs and revenues in relation to volume. However, it should be mentioned that "break-even" is a somewhat unfortunate term. It tends to distract attention from the central problem of analyzing operating data within expected or experienced ranges of output, typically *not* centered on the break-even point.

Studies of the Economists: What They Say About Variables

Historically, there have been two main paths along which work in break-even analysis has progressed. The first of these lies in the field of economics, where the theory of cost as it relates to a business enterprise has long been a subject of study. The object of the economists has been to describe with precision the basic behavior of cost in relation to volume. Linking this to their theory

of the demand for a product, they have gone on to explain in their own terms why a company produces at a certain price and a certain level of output. Without probing the economic theory of the subject, it may be pointed out that, at the present time, economists are generally well satisfied with their theoretical formulations of the cost-output relationship for an individual company, although many express the need for more investigation and research in this area. A few significant studies have been made by economists to actually test the economic conceptions of cost in an industrial situation.

In the economic research which has been done on cost, one of the important points which has been at stake is the question of whether unit variable costs fall and then rise with expanding output or are constant in their variability. Putting it another way, this is the same question as whether total variable costs should be expressed as a curve or as a straight line in diagrammatic presentations. Somewhat contrary to theory, the research investigations of economists have concluded, in general, that unit variables are constant throughout the relevant ranges of volume, that is, total variable costs increase at a constant rate. This conclusion is of particular importance to accountants because straight lines are typically assumed as reasonably representative of the cost-output relationship in break-even analysis. As long as we are not lulled to sleep in our attitude toward cost behavior, it is reassuring to know that this straight-line assumption has some measure of theoretical and scientific backing.

Interests of Industrial Accountants in Break-Even Analysis

The other path of progress has been in the development and application by industrial accountants of various techniques of cost analysis for the practical solution of company problems. The use of profit-volume data as an aid to the formation and review of company policy has grown naturally on the broad base of cost knowledge provided by accounting and budgeting procedures. However, the specific analytical technique exemplified by the break-even chart was given its major impetus by management engineers. At the present time, we find some of the most important management problems, such as pricing policy, cost control, and investment planning, being expressed in break-even point terms.

The necessary elements of a break-even analysis are the determination of the relationships between cost, revenue, and output.

The actual analysis may be historical or projected, that is, it may be simply a study of past operating data or it may be an attempt to project the profit-volume relationship into the future. Its purpose, however, is typically forward-looking in that it is designed to aid in making *now* decisions or plans for the *future*.

The starting point in practical break-even analysis is the determination of cost at various levels of output. The determination of the other side of the profit picture, revenue, is typically not considered a part of the accounting problem, except to the extent that sales volume enters into the measurement of output. The reason for this emphasis on cost stems more from considerations of convenience and division of labor than from any minimization of the revenue aspect, the latter being regarded as primarily a problem of market analysis and price policy. Once cost at different levels of volume is determined, the analysis can ordinarily be adapted for use with any given set of sales possibilities. Thus, we have what is primarily a cost analysis job consisting of two major elements: (1) defining output, and (2) relating cost to output.

Dollar Measures of Output

In establishing the cost-output relationship for a company, the most commonly used measures of volume are sales value of production or per cent of capacity based upon ability to sell. The advantage of these bases lies in their simplicity. In the typical case, where more than one product is involved, dollar sales is an obvious common denominator. Where a break-even analysis is based upon historical data, dollar sales in relation to costs are almost always available and are easier to use than sales or production in terms of physical units. Also, in cases where a break-even analysis is built up from standard cost data, the dollar costs and standard selling prices can be readily used in the process of arriving at the cost-output relationship.

The theoretical objection to these bases lies in the disturbing effects of a shift in product mix or of a change in selling price. Suppose, for example, that we want our break-even analysis to tell us quickly what our total cost will be at some given level of sales, say one million dollars, for next year. If our break-even chart is one which was constructed with sales value of production as the measure of output, we must satisfy ourselves, first, that the million dollar sales figure is at approximately the same prices as those originally used in measuring output and, second, that the

assortment of products which will make up the millon dollars of sales is essentially unchanged.

These same problems can arise in making the analysis as well as in using it. The possibilities for distortion stem from the variety of alternative combinations of cost-price relationships existing within a company's product line. Consequently, whenever sales value of production or per cent of sales capacity are used as measures of output, care must be taken that users are not seriously misled by the effects of *variances in product mix and in prices.*

Physical Measures of Output

Similar theoretical objections can be raised against physical capacity measures such as machine hours, labor hours, tonnage produced, etc. It is extremely difficult in most plant situations to define capacity in such a way that cost can be satisfactorily related to output in a variety of operating situations. More often than not the same "capacity" can be achieved in a variety of ways, each with a different total cost. Materials cost often presents a particularly serious problem in this respect because of its lack of association with capacity as such.

Unfortunately, the single product company, which is ideal for break-even analysis purposes, is the rare exception rather than the rule. Where only a single product exists, output can be defined readily as units of product. The problem of relating cost to this output is still subject to the effects of price fluctuations and changes in plant size and manufacturing technique, but the possibilities for the entrance of distorting influences is at a minimum. However, more than one product exists in the vast majority of cases. It is possible to construct a physical-production index with cost-weighting factors for each product in order to arrive at a more versatile measure of output, that is, one which is adaptable to shifts in product mix. Needless to say, this type of solution is too complex for practical use. The problem of converting sales or production data to the index every time the chart is used is, in itself, sufficient to greatly reduce the usefulness of the analysis as a working tool.

It is for these reasons that the ordinary development of break-even point data has been based on simple measures of output and has proceeded on the assumption that the product mix is essentially constant throughout the relevant ranges of output. The result of this procedure is that, in multiple-product situations, a sin-

gle cost-volume relationship is used as being reasonably representative of what is actually a series of basic cost-output relationships, each associated with a different product or product-price mix. Failure to realize that this simplification exists may lead to distorted judgments in the use of the chart.

Determining Cost Behavior: "Annual Statement" Approach

The second problem in break-even analysis is that of relating cost to output. The objective is to determine the manner in which costs behave in order that a level of cost may be associated with each level of volume. In organizing this information a variety of methods are used, ranging all the way from the simplest interpretations of operating statement results to intensive account studies similar to the methods employed in establishing flexible budgets. The strength or weakness of any break-even analysis depends very largely upon the validity with which this cost-output relationship can be established.

Perhaps the simplest approach to this problem and the one yielding the crudest results is the use of operating statements for a series of years. Each year's sales, and corresponding costs (expenses) are plotted against sales volume, thus furnishing points in a scatter chart to which straight lines are fitted. The result is two lines representing the basic historical relationship between sales, costs, and profits in relation to volume levels experienced by the company. In making such a study, the effects of price level changes must be removed by deflationary techniques to obtain even a moderate degree of accuracy. Unfortunately, this is only one of the distortions present in this type of data. Changes in plant size and production methods are almost certain to occur in any company over a period of years. These different conditions of production cannot appropriately be combined, without careful adjustment, to arrive at the cost-output relationship which exists now and will prevail in the immediate future.

In spite of these difficulties, this "annual statement" approach to break-even analysis is useful where changes in the conditions of production have not been extensive and when only generalized results are desired. Its biggest advantage lies in the fact that it can be used as an approximate method by investment analysts, economic research specialists, and others who do not have access to more detailed data. This method is also very useful to company accountants in situations where a break-even chart is wanted with

a minimum expenditure of time and effort. I feel that one of the best published studies of this character is that made in 1940 by the United States Steel Corporation and offered in testimony to the Temporary National Economic Committee.

Determining Cost Behavior: Detailed Studies

A more thoroughgoing approach to the problem of relating cost to output calls for the use of detailed cost data rather than summarized annual results. This can be done on an experience or estimated basis or on some combination of the two. It is the kind of method necessary where accurate results are desired for the guidance of management in coping with specific problems. A typical starting point is a historical analysis of monthly data over a year or somewhat longer period. A study of individual cost elements (i.e. direct labor, materials, indirect labor, power, etc.) is made department by department, or cost center by cost center, in order to establish a series of basic cost-output relationship. A scatter chart is prepared for each cost element in each department. The fixed or nonvariable portion of each cost is determined directly from observation or arrived at indirectly by back plotting from experienced cost levels. Linear relationships between the measure of output and the cost element are fitted by inspection or by statistical techniques. Selling, administrative, and other nonfactory expenses are likewise related to the various levels of sales. The data are then combined into a complete break-even chart for the entire company.

This is a very brief description of what is actually a lengthy and complicated process. The end product in a typical case is a substantial amount of organized information regarding the normal cost-output relationships existing in the company. From this, the data can be recast into projections covering one or more fiscal periods.

The two approaches described above are the most widely used but they by no means exhaust the possibilities. Where up-to-date cost standards or flexible budget data are available, the cost-output relationship can be derived directly from this data with relative simplicity. This is very frequently done as a final step in budgeting procedure, with the break-even chart portraying what is sometimes called the "master budget." Whether this method gives rise to a realistic break-even analysis depends upon the manner in which the basic cost standards have been derived. Very frequently, the level of allowable costs under flexible budget arrange-

ments is somewhat too stringent to serve as a basis for break-even analysis where a full recognition of expected costs is desired.

Contrasts in the Approach of the Accountant and the Economist

Another aspect of this problem of relating cost to output is the question of whether the process of break-even analysis determines, fundamentally, a true cost-output relationship. For example, the primary interest of the economist is in what he calls the "pure cost function." By this he means the cost-output relationship when all factors except output are held constant. This would assume that there are no changes in the size of the plant, the skill of the workers, the methods of production, or the prices paid by the company. Knowing this relationship, the economist would explain a particular situation by introducing changes in the conditions of production, each change precipitating a shift in this basic cost function. Obviously, these assumptions and others which are posed by the economist are rarely fulfilled in practice. In the research studies on cost which have been made by economists, primary effort has been directed toward removing extraneous factors in order to test the theoretical concept.

The practical break-even analyst, on the other hand, by-passes many of the niceties posed by this theoretical interest. His interest in cost and profit planning leads him in the direction of making full recognition of costs rather than toward the verification of a concept. In analyzing past behavior, he usually deals knowingly with time periods during which some changes in plant size, production techniques, and other factors have occurred. Also, monthly data more often than not embody such a range of output levels that no attempt is made to answer in fine detail the question of what is cost at a certain capacity. Furthermore, in attempting to establish projected cost levels, the cost accountant attempts to allow for likely deviations rather than to focus attention on the precision of fundamental relationships.

Another area of difference is that, in general, practical break-even analysis intentionally maintains allegiance to account classifications and accounting measurements, whereas the economist would tend to be critical of them. On the subject of expense timing, for example, the economist might be critical of the point that this month's maintenance is associated with this month's production, and might suggest that it is a cost of the production initially

causing the wear and tear. Questions of this sort are by no means entirely glossed over by the accountant. Practically speaking, however, if a company's maintenance policy calls for outlays or allowances at a given level of production, this is sufficient grounds for him to establish the incidence of such outlays as a cost associated with that level of production. These and other points are important when the theoretical relationship between cost and output are being tested, but it is doubtful that they have a significant impact on the cost side of break-even analysis.

Finally, it should be pointed out that a substantial portion of the everyday techniques of differential costs and break-even analyses are conditioned by the need for simplified expositions of what are the essential facts. The skill, time, and money are not usually available to enable accountants to go the whole way in making careful estimates based upon extensive research, particularly when rapidly changing conditions introduce margins of error wider than any which can possibly exist in the deviation of their projection data.

General Uses of the Break-Even Chart

The end product of break-even analysis, the break-even chart, serves to summarize the cost and profit structure of a company. In doing this, it puts in perhaps as simple a form as is possible the complex but basic facts concerning the company's operations. The usefulness of break-even analysis follows primarily from this simplicity. In such form, it may be employed as a basis for managerial plans and decisions or for any purpose where an understanding of the company's total cost-profit structure is desired.

It is evident from the amount of publicity which has been given break-even points in recent years, that the ideas and terminology of break-even analysis are felt to be a useful means of illustrating the basic problems of operating a business under today's conditions. Articles in newspapers and trade publications have frequently used break-even point concepts in outlining the important factors which are contributing to the present inflationary cost-price relationships and the kinds of steps which management might take in adjusting itself properly to present and future conditions. Whether public education on the subject of costs and profits would be furthered by giving more extensive publicity to this subject is a question deserving some kind of answer. It is almost certain, however, that any price, wage, or employment adjustments which

industry may make in the future will be explained in break-even point terms, if for no other reason than that these seem to be an understandable way of referring to costs, profits, and losses, and the risks of oversimplification are not generally weighed.

Managerial Uses of the Break-Even Chart

From the standpoint of internal management, the break-even chart has found use primarily as an aid to the education of managerial personnel regarding the company's cost characteristics. Some people feel that the primary benefits of break-even analysis stem from the cost education involved in building the analysis regardless of what use can be made of the end product. In many instances, the controller has assumed the continuous responsibility of keeping the other executives informed in this respect, the break-even chart being prepared and kept up to date for this purpose. On the other hand, the view has been expressed that "a little education is a dangerous thing" and that the break-even analysis and its resulting chart should be kept primarily in the hands of those who are capable of dealing with the data intelligently. It is certainly clear that there is danger in looking toward break-even analysis as an easy mechanical substitute for the complex art of managing a business.

Some of the specific uses of break-even analysis most frequently mentioned are as follows:

Establishment of output level and profit goals.
Review of price policies.
Selection of product lines.
Establishment of the "normal" volume level for burden rates and budgeting purposes.
Guidance in facility usage and in new investment decisions.

The more ardent supporters of break-even analysis place an unlimited amount of faith in this technique. The impression is gained from them that the chart is the single invaluable instrument by means of which a company's management can plot its course and make important decisions concerning the utilization of its resources. Actually, break-even analysis, like any managerial tool, is valuable for what it is capable of telling us about the facts and implications of an established or prospective course of action. When a problem is posed, break-even analysis is *one* place to look for light on the subject.

Strengths and Weaknesses of Break-Even Analysis

A note of warning should be sounded against drawing oversimplified conclusions from the construction and use of break-even charts. Perhaps the most commonly expressed deduction about business operating conditions today is that the break-even point is too high and that what is needed is a reduction in fixed cost—certainly not an increase in fixed cost. As a result, plant improvements may meet with opposition because higher fixed costs are usually involved. In this situation, the operating savings resulting from suggested improvements and the market permanency of expanded output must be considered at the same time. The history of successful companies is typically one of expanding and improving plant, which inevitably means increasing fixed costs and raising break-even points. In fact, it probably is true that technological development in general leads unavoidably—but not necessarily undesirably—to higher break-even points. A rise in fixed costs will raise the break-even point, but may often make operations more profitable at the normal level through reductions in variable costs or as an offset to rising variable costs such as labor or materials. This point is made, not to minimize the dangers of rising break-even points, but to emphasize that care must be exercised in distinguishing the desirable objectives of cost control and cost reduction from equally well-founded measures of plant expansion and improvement.

Some of the weaknesses of break-even analysis which were dealt with earlier arise from theoretical and analytical inaccuracies in the technique of measurement. The cost-output relationship is elusive, and particularly so when one is trying to project it. Another weakness of break-even analysis, however, stems from the same source as its strength. The end product is a highly summarized piece of information, making it difficult to use on a practical basis in the solution of specific problems. Nevertheless, much more seems to be gained than lost through this achievement of organizing a complex mass of information into meaningful and useful terms for managerial use.

Because of the fact that break-even analysis deals with the behavior of cost, it is common ground for the economist and the accountant and should furnish the basis for advancement of the knowledge of each in the field of costs and profits.

DAILY REPORT BASIS FOR PLANNING AND CONTROL IN THE FLOUR MILLING INDUSTRY

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Dealing with a line associated over-much in the public mind with the operation of hedging purchased raw materials by product sales contracts or market futures, the author of this paper gives due weight to the importance in flour milling companies of control techniques common to all industries. Among forms illustrated is a daily cost card requiring forecast of cost elements related to sales contracted at specific prices for delivery in a specified time.

IT USED to be said that a cost accounting system was of little value in the flour milling industry because, regardless of the costs, flour had to be sold at a price based on the current wheat market, which fluctuated daily and sometimes quite drastically from day to day. While it is true that the price of flour is closely geared to the commodity market of the raw material, many of the elements which make up the total cost of producing a hundredweight of flour do not fluctuate quite so frequently or so much and are susceptible of being predetermined and, to a great extent, of being controlled. Some of those elements are: containers, labor, fixed charges, manufacturing burden, selling and administrative expenses.

The fact is, and always was, that the price the miller quotes must cover, in addition to the variable wheat cost, all of these other items of cost, plus a margin of profit, if he is to stay in business. It is just as necessary, therefore, for the miller to have an accurate knowledge of his costs as it is for any other manufacturing executive.

Growth of Flour Mill Cost Accounting

With the development of modern milling machinery and technology, mass production, milling to laboratory specifications, diversification of product, imposition of numerous governmental regulations and many other similar things which have been common to most industries in this century of progress, the making and merchandising of flour has become a highly complex business. Profits and losses now are affected to a considerable degree by many intangible factors such as: fluctuations in wheat prices and

premiums, in feed, in clears (low grade flour), the impact of overtime pay for labor, changes in transportation rates, and many others, as well as from the ordinary problems of production and selling. All this has required the keeping of far more detailed cost and operating records and has made departmentalization necessary so that sources of gains and losses may be currently determined and information provided to help management maintain profits and minimize losses.

The adoption and development of sound cost accounting methods and systems to provide complete, accurate, and current costs of production and merchandising operations has long ago become imperative in the flour milling industry. The cost accounting department has consequently become an increasingly important department of the milling business.

An adequate cost system for a flour mill can be comparatively simple. Most plants in the industry produce only one main product and all cost factors can be expressed as so much per hundredweight of flour. However, there are certain conditions peculiar to the milling industry which require special accounting treatment. One of these, the valuation of inventories, was very ably analyzed in an article entitled "Valuing Flour Mill Inventories," by Ralph C. McKibbin, published in the *N. A. C. A. Bulletin* of May 1, 1947.

But simple as it may be, a comprehensive analysis of the cost accounting system of a modern flour mill would constitute a quite voluminous manual. This present article, therefore, will not go into detail about the routine procedures of cost accounting which are similar to those in other industries but will be confined to some points which require special adaptation and application in flour mill accounting.

Separation of Grain Purchasing and Milling

It has been found advisable, in the flour milling industry, to separate the purchasing functions, in so far as the basic raw material, wheat, is concerned, from the other functions of the business. This is because of the fact that even with the best intention and practice, there is bound to be some speculative profit or loss in purchasing grain. Most mills try to minimize this speculative element by purchasing only enough wheat to cover actual sales of flour made. But it is not aways possible, and sometimes not practicable, to make cash purchases of the amounts and kinds of wheat needed, so most flour mills have adopted the policy of "hedging"

flour sales, when made, by the purchase of options in the wheat futures market.

Also in many cases, particularly at harvest time, it is necessary for mills to buy large quantities of wheat while it is available in anticipation of future flour sales. This means that a mill will often own, or have contracted, much more wheat than the equivalent of flour orders on the books. To protect themselves against the effects of market changes in this excess supply of wheat, many mills will also sell wheat futures so as to balance their wheat position with their flour sales. This procedure of buying and selling options in the futures market is the practice commonly referred to as "hedging."

Interdepartmental Contracts

In order to isolate the effects of these grain operations, a good many mills use a system of accounting which separates the profits and losses that are due to the grain market fluctuations from the profits and losses that arise from manufacturing and merchandising the mill's products. This is accomplished by a system of orders and commitments, known as "interdepartmental contracts," between the grain department and the mill department, which requires that the mill department purchase from the grain department the wheat equivalent of its flour sales each day at the "daily cost card" value. This means that the wheat position of the mill department will always be in balance. The "long and short" position will rest in the grain department and all of the profits or losses resulting from buying and selling grain will be established and segregated as belonging in the grain department.

The grain department maintains a record of interdepartmental contracts showing all the pertinent data in regard to each sale of grain to the mill department. These contracts bear the same number as the corresponding flour sales contract and from this record it can readily be determined what amount to charge the mill department for each lot of wheat ground in fulfillment of that contract.

The grain department also maintains a position record commonly called the Long and Short Report, which shows the daily wheat position in relation to unfilled flour orders, bringing out any lack of balance which may be rectified by buying or selling as the occasion requires. In Exhibit 1 is shown a typical example of a long and short report.

LONG & SHORT REPORT

8:00 A.M. _____ 19__

	(Bushels)	(Bushels)
Wheat in Mill Elevator - last report		_____
C. L. Wheat Unloaded	_____	
L.C.L. Wheat Unloaded	_____	_____
TOTAL - Inventory & Receipts		.....
Deduct:		
Wheat Ground since last report	_____	
Wheat Shipped since last report	_____	_____
Balance - Wheat in Elevator - this report -		_____
Add:		
Purchased Wheat in Transit	_____	
Wheat at Country Elevators	_____	
Wheat Stored with Others	_____	
Options Bought	_____	_____
Total - All Wheat Stocks & Options		.....
Deduct:		
Wheat Stored For Others	_____	
Wheat Sold but Not Shipped	_____	
Options Sold.	_____	_____
Net Wheat - Available for Flour Sales		.....
Unfilled Flour Sales Contracts:		
_____ CWTS. @ _____ Bus. (Standard Yield)		_____
BALANCE - LONG (if positive figure		_____
SHORT (if negative figure)		_____

EXHIBIT 1

Adoptions of Standard Costs and Budgets for Operating Control

The inherent defects of the historical method have long been recognized in the accounting circles of the flour milling industry. This has been particularly true in recent years when costs have been rising so rapidly and so radically. In such circumstances, certainly the experiences of the past year or even the previous month are not a safe guide nor an accurate yardstick for projecting future performance.

Many of the most successful mills in the country have, therefore, adopted various forms of budgets and budgetary control using the standard cost method and comparing actual costs with standards at frequent intervals, usually each month but sometimes, as in the case of payrolls, even weekly. Whenever the variations indicate a marked trend it is often advisable to adjust the standards. Here again the accounting procedures are much the same in the milling industry as in other manufacturing industries with one notable exception. In the milling business, budget standards cannot be applied to wheat costs. The cost of wheat can be accurately determined only on the basis of the daily market. Consequently, for costing their product most mills use a Daily Cost Card.

Budgeting Principle Embodied in the Daily Cost Card

Whether or not a mill manager has adopted a formal budget, he is forced by the very nature of the business to deal with various cost factors embodied in the principle of the budget. Flour is customarily sold under a sales contract, the terms of which require the miller to deliver a definite quantity of flour of a certain quality, at an agreed price within a given period of time, usually 120 days, but sometimes longer or shorter. In making such forward sales of flour the miller must accept the position of predetermining his costs. Even though he may be able to buy the wheat at the figure used in his cost card, he still must forecast what the feed by-product and the low grade flour, if any, will bring on the market at the unknown future date when the flour will actually be made and shipped. This is because a corresponding credit for the by-product must be allowed in figuring the price of the flour.

In addition, all the other factors in the cost card must be based on standards of one kind or another, so that it may be said with a great deal of truth that the daily cost card is, in effect, a form of budget. In making a sale based on his cost card the mill manager places himself under the necessity of exercising all the controls within his power to assure that the promise of the cost card will be realized in the ultimate performance.

This daily cost card is an orderly and systematic daily compilation of all the cost elements which it is necessary to treat in the process of determining a reliable basis on which flour must be sold to yield a profit. It is the most important current cost record in use in a flour mill. The degree of thoroughness and accuracy with

DAILY COST CARD
(Pricing Basis)

Date.....19.....

1. Cost of Wheat Mix

Grade or Variety	Price per Bushel F.O.B. Kansas City	Percent in Mix	Cost
Cost of Wheat Mix, per bu.		100%	$

Price includes.....¢ premium. +

2. Mill-Feed Credit

Market price, K.C., per cwt. .....$

Less: Cost of Sacks.....$

Selling Expense.....

Safety Factor.....

Credit Value of Mill-Feed, per cwt. ....$

3. Clears Basis

	First Clear	Second Clear
Market price, K.C., per cwt.	$	$
Less:		
Cost of Containers.....$		
Manufacturing Cost.....		
Administrative Cost....		
Selling Costs.....		
Profit Margin.....		
Credit Value of Clears, per cwt. . . .$		$

EXHIBIT 2

which it is compiled and the degree of fidelity with which it is applied will determine the result of the mill's operations.

The daily cost card is prepared according to a carefully planned formula somewhat as follows:

Cost of Wheat—At market value, including premiums for kinds and grades required, multiplied by standard yield (bushels per hundredweight).

Conversion—Manufacturing, administration, and office selling expenses, at standard unit costs per hundredweight.

Credits—Deductions for feed and low grade (or clears) at market or anticipated price, using a safety factor for possible market variations.

Other Costs—Cost of sacks or other containers, plus freight. Freight to destination, for delivered basis. Branch office costs or brokerage fees.

Add—Profit Margin

Net Total—Selling Price

Exhibits 2 and 3 show the various steps and computations to be made in applying the above formula in the preparation of the daily cost card and also for applying the cost card to a particular sale.

SALES COST CARD

Customer..... Date.....19...
Address.....

Brand or Specifications... ..... Quantity.....CWTS.

1. Cost of Wheat Mix per cwt. of ____% flour:
   _____Bu. @ $_____(basis price).....$.....
2. Less: Feed credit on ____% flour:
   _____Lbs. @ $_____(basis price)per cwt. .....
3. Cost of Wheat less Feed credit, per cwt. ....
4. Clears differential for patent grades:
   (Deduct for short patent; add for long patent)
   _____Lbs. 1st clear @_____cwt. ..$.....
   _____Lbs. 2nd " @_____cwt. .. .. _____
5. Net Material Cost of 1 cwt. of _____% flour .....$.....
6. Add: Expense-
   Manufacturing (at standard) $.....
   Administrative " " .....
   Office Selling " " ..... _____
7. Net Bulk cost, F O.B. Kans. City, of 1 cwt.____% flour$.....
8. Add: Other Costs:
   Cost of Containers .....$.....
   Freight or trucking..... .....
   Outside Selling Cost .... _____
9. Net Cost, delivered, 1 cwt. of ____% flour .....$.....
10. Profit(add)
    Loss(deduct)..... $ .....
11. Selling Price ..... $.....

Sold By..... Contract Number.....

EXHIBIT 3

Present Trends and Future Prospects

The present trend in flour mill cost accounting seems to be in the direction of more and more detailed and complicated cost systems and reports. This is an inevitable outgrowth of the ever-increasing mass of detail and complications surrounding the transaction of business in our modern economy. It is also partly the result of the competitive struggle and the desire on the part of management to control costs in every department and to reduce costs wherever it is possible in the interests of better performance. However, some mill accountants are beginning to recognize that there is a dire need also for simplification and directness in many areas of mill accounting. In 1943 the industry generally adopted the hundredweight as the unit for flour, replacing the age-old barrel basis with its many odd subdivisions. This action eliminated several package sizes and greatly simplified many procedures, such as pricing, inventorying, handling sacks, etc. At the present time there is another movement on foot to adopt the hundredweight as the unit for trading in grain. If accomplished, this would also help to simplify flour mill accounting.

In the field of cost reporting and cost control, while it may be necessary to compile more detailed statistics and cost information, by the same token it will be necessary to find more simple and direct methods of digesting and interpreting the figures and of presenting the facts to management. Charts and graphs and other pictorial forms of presentation must be better adapted and more widely used. Standards must be devised which will better measure the relation of unit volume to dollar volume and take into account the effects of inflation on both the cost system and the capital structure. Improved yardsticks, such as the "break-even point" formula, must be adapted for measuring performance. The field is wide open and limitless for accountants with imagination and initiative to improve their usefulness to management in its continuing struggle to keep our system of free enterprise functioning successfully in our changing modern world.

READY DETERMINATION OF ECONOMIC LOT SIZE IN SMALL AND LARGE COMPANIES

by NORMAN T. HARRISON

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Consideration of all costs significantly affected by the quantities for which production orders are written, is advocated in this presentation. Two procedures are offered for prompt determination of the most economical quantities of specific products to make in a single lot. The first of these is reported by the author as applied in a company manufacturing 100 components. The second is in use in a company making 30,000 components.

ONE of the factors in production planning having a major effect on manufacturing costs and on the amount of funds invested in inventory but, paradoxically, one which is frequently given too little study, is the determination of the number of pieces for which a production order should be written. The economical lot size may be defined as that quantity which can be produced at the lowest possible unit manufacturing cost. Adequate consideration must be given to those variable manufacturing costs which are influenced by the lot size of the production order.

Conflicting Considerations in Setting Production Order Quantities

Funds invested in inventory represent, in most manufacturing companies, a substantial part of the working capital of the business, yet management, although fully recognizing this fact, will freely admit that it does not exercise as complete a degree of control over such funds as it does over the more liquid assets of the enterprise. Control of capital invested in inventory of self-manufactured articles frequently rests in the hands of experienced rank-and-file employees who, in effect, determine the amount of this investment by exercise of judgment based upon their own past experience. However, the widely varying results received from simple tests of the judgment of employees of similar experience prove the inadequacy of this method. In other cases, instructions from management are issued to order manufactured articles or components on a specific time basis, such as a four months' supply for articles in a particular inventory group. Whereas this method is undoubtedly effective in controlling the level of investment in

inventory and the costs of maintaining such investment, it often does not take into consideration the usually more important factor of variable production costs.

In most cases, the plant executive, who is primarily concerned with economical, large-lot shop operation, and the sales executive, who is interested in providing quick, efficient service to customers, exert a considerable degree of influence upon the amount of inventory carried and upon the lot size of the production orders written. In many instances, they work at cross purposes rather than in cooperation. Thus, all too frequently, the production and inventory patterns vary between a low or out-of-stock condition with lower carrying costs but higher production costs and a high inventory condition with higher carrying costs (and the consequent inventory risks involved) but lower production costs.

It is in establishing a definite and consistent balance between these conflicting forces, in providing a procedure or tool for determining the economic lot size of the production order, that the professional or cost accountant can render an invaluable service to management.

Principal Costs Influenced by Lot Size

Many specific production costs, of which the following are usually the most important, are influenced by the lot size of the production order:

1. Cost of preparation or setup time
2. Cost of machine or run time
3. Cost of writing production orders and of handling and accounting for material during processing
4. Space cost for storage
5. Interest on funds invested in inventory
6. Obsolescence
7. Deterioration in storage

All of these items need serious consideration, including the numbers 3 to 7, seldom fully allowed for. The effect of clerical and handling costs, cost of carrying inventory, and interest on funds invested in inventory should not be discounted as unimportant, for such costs are frequently higher than estimated or assumed. The factors of obsolescence and deterioration in storage obviously vary widely according to the nature of the manufactured product. These

costs should not be casually dismissed, however, without sufficient study to determine their effect on over-all production costs.

It is important therefore: (1) that a careful cost study be made of all factors having a bearing on the accurate determination of the economic lot size in the particular situation and (2) that such cost factors be properly weighed and evaluated before being reduced to a formula. When this is done, it is possible to obtain a simple formula or computation for any given manufactured product which may be expressed graphically so that the result can be read directly from a chart without detailed computations, if the number of manufactured components or products makes this desirable.

LOT-SIZE CONTROL CARD

Part Number	Description	Date
849	Gear	10/7/48
Standard Cost Per Piece	**Set-up Time Per Order**	**Processing Time Per Piece**
$50	10 Hours	1 Hours
Annual Requirements	**Labor Rate Per Hour**	
100	$1.50	

Number of Orders Per Year	1	2	4	5	10
Number of Pieces Per Order	100	50	25	20	10
Yearly Cost Varying With Lot Size:					
Labor - Set-up	$15.00	$30.00	$60.00	$75.00	$150.00
Writing Order and Shop Handling	5.00	10.00	20.00	25.00	50.00
Carrying Cost, Obsolescence, Interest on Capital, Etc.	$250.00*	125.00	62.50	50.00	25.00
TOTAL YEARLY COSTS VARYING WITH LOT SIZE	$270.00	$165.00	$142.50	$150.00	$225.00

*Computed at 10% of average inventory value - - 100 pieces x $50 cost equals $5,000 - - Yearly average $2,500 - - 10% equals $250.

EXHIBIT 1

Procedure for a Company Manufacturing Few Components

The following method was suggested and adopted for a manufacturing plant having approximately 100 different manufactured components. Its installation required little if any training for stock or ordering clerks, since it utilized information which in most cases was already available to them.

A study was made of the cost factors which were influenced by the lot size of the production orders written and the following data were derived:

Cost of writing production order and shop handling, per order	$5
Cost of carrying inventory, obsolescence and interest on investment	10% of cost of average inventory
Cost of preparation or setup time in relation to machine or run time	Variable

A Lot Size Control Card, as illustrated in Exhibit 1, which indicated at a glance the economic lot size for the particular part to be ordered, was then set up for each manufactured part or component. Exhibit 1 shows a method for properly weighing the variable cost factors influenced by the lot size of the production order and, in the case of the particular component illustrated, indicates that the economic order lot size is 25 pieces. It further indicates that the total yearly costs which vary with the lot size of the order aggregate $142.50 for the economic lot size, which is 47 per cent less than the like costs, $270, for an order written for 100 pieces, and 36 per cent less than those costs, $225, for an order written for ten pieces.

The method is not too cumbersome for a plant having up to a few hundred manufactured components and can be installed with very little, if any, interruption of normal procedures. In the situation where it was applied, it provided a realistic method of determining "that quantity which could be manufactured at the lowest possible unit manufacturing cost," mentioned earlier, and has resulted in a gratifying reduction in manufacturing costs over the period of time during which it has been in operation.

Procedure for a Company Manufacturing Many Components

The following method of determining order quantities at the point of lowest unit manufacturing cost was recently developed for

a machine tool plant which manufactures approximately 30,000 different component finished parts. A preliminary study of the problem revealed the following information:

1. Annual requirements varying from 2 to 150 pieces with an average of approximately 40 pieces.
2. Machining operations varying from 5 to 25 operations.
3. Ratio of setup time per order to machine time per piece varying from 1/2 to 200/1, but most jobs within the range of from 6/1 to 100/1.

A cost study was then made of all the variable cost factors influenced by the lot size of the production order and it was found, because of the inherent nature of the manufacturing processes, that the factor having the preponderant effect on production costs was the relationship of setup to running time. A chart was then prepared as shown in Exhibit 2 which illustrated graphically, at various ratios of setup to run time, the percentage of reduction in setup labor costs which could be obtained at various order lot sizes as compared with the cost of an order for one piece only. The percentages of reduction in setup labor cost at various lot sizes (as compared with an order written for one piece) are indicated in Exhibit 2 by the curved lines.

It will be noted that the curved lines (representing the percentages of reduction in setup labor costs over a one-piece lot) climb sharply in a narrow area (lot sizes of from one to ten pieces) and level off in a wide area (lot sizes of from ten to 100 pieces). An intersecting line, the "10% line," was therefore drawn so as to indicate the *minimum* point in lot size on each of the curved lines at which a cost reduction or saving could be retained, within ten per cent of the reduction to be realized by ordering 100 pieces. The most important cost factor varying with the lot size of the production order was thus charted effectively.

Reading the Chart

The effect on over-all production costs of the variable factors of carrying costs, obsolescence, and interest on investment in inventory, obviously change only with the size of, or number of dollars invested in, the inventory. It was decided, therefore, that those cost factors could be controlled merely by setting down instructions as to the *application* of the chart to the determination of the lot

LOT SIZE CONTROL CHART
Setup to running time 10 to 1
Setup to running time 4 to 1
Setup to running time 2 to 1
Setup to running time 1 to 1
Setup to running time 1 to 2
10% Line
This line marks the minimum lot size which will retain within 10% of the reduction in costs made possible by ordering 100 pieces
(1) Order four months requirements, unless -
(2) That quantity falls to the left of the 10% line,
(3) When this occurs, order at the 10% line, unless -
(4) That quantity is in excess of one year's requirements.
(5) Do not order in excess of one year's requirements.
PER CENT OF COST REDUCTION OVER SIX PIECE COST
NUMBER OF PIECES (LOT SIZE)

sizes. An example of these instructions is shown in the lower right-hand corner of Exhibit 2.

Thus if Part No. 847 having a ratio of setup time per order to run time per piece of ten to one has reached the minimum ordering point, it would be ordered on the following basis:

1. If usage is at the rate of fifteen pieces in a four months' period, the production order would be written for fifteen pieces, inasmuch as that point is to the right of the ten per cent line and the cost reduction would be within ten per cent of the reduction possible by ordering 100 pieces.
2. If usage is at the rate of six pieces in a four months' period (eighteen pieces per year), the production order would be written for nine pieces (the lot size indicated by the ten per cent line) so as to retain within ten per cent of the reduction in cost possible by ordering 100 pieces.
3. If, however, usage is at the rate of one piece in each four months' period (three pieces per year), the production order would be written for three pieces. This would sacrifice approximately thirty per cent of the reduction in cost possible by ordering 100 pieces, but would limit the order to one year's supply of the particular component.

It should be noted that the variable factors of carrying cost, obsolescence, etc., may be given greater or lesser weight due to changing conditions merely by a change in the instructions for application of the control chart to the ordering procedure, or by drawing a vertical intersecting line (similar to the ten per cent line) at the focal points of any percentage of savings desired.

Through the development of the chart and routine, management was provided with (1) a procedure or tool for controlling these important factors of production cost within a definitely prescribed area and (2) a means of exercising direct control over inventories through the formulation of the instructions to the ordering clerks for the actual application of that tool.

COMING ARTICLES

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